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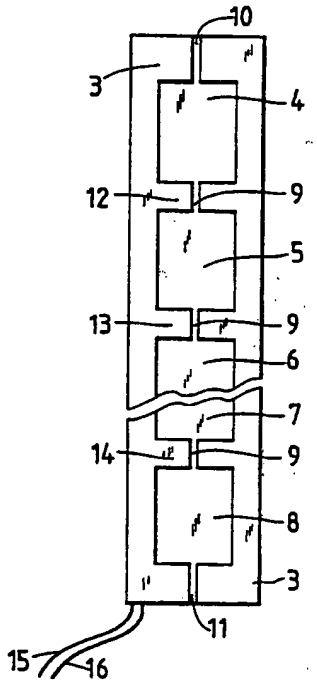
(54) Title: A PRESSURE SENSOR

(57) Abstract

A pressure sensor which comprises two elongated thin and plate-like elements which are spaced from one another at given locations along their lengths by means of a spacer member, and which sensor is configured so that an electric contact is established when the two elements are brought into contact with one another. The spacer member has the form of a thin plate from which sections of material have been removed so as to form a plurality of cavities or apertures between the elements, these cavities being disposed in successive, sequential relationship along the length of the sensor. The invention is characterized in that all cavities (4-8) are connected to atmosphere through air passages (9-11) which extend in the spacer member (3), and in that at least a first (1) of the plate-like elements intended to be subjected to a pressure force from a person or an object is made of a metallic springy material, and in that both of the elements (1, 2) are electrically conductive so as to close a current path between two electric conductors (15, 16) extending to a respective element (1, 2) irrespective of the cavity (4-8), in which the elements (1, 2) are brought into contact with one another when the pressure sensor is subjected to a force from an object or a person.



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A PRESSURE SENSOR

The present invention relates to a pressure sensor.

There is a great demand for pressure sensors which will, inter alia, enable the presence of a person or an object to be detected. A plurality of mutually different pressure sensors intended for this purpose are to be found, such as sensors for detecting whether the occupier of a car seat is wearing his/her safety belt and to control a safety-belt warning system, sensors for detecting the position of goods in a given location for the purpose of controlling and activating transporters etc. Sensors of these kinds are to be found in many different designs.

Not known to the art, however, is a sensor which is extremely thin and which is able to detect a pressure or a force applied at any position along a significant length. One example where the use of such a sensor is desirable is found in the supervision of patients who suffer from a dementia illness, so as to give an indication that a patient has left his/her bed for instance during the night hours. When such a sensor is placed beneath the mattress so as to extend in a direction perpendicular to the longitudinal axis of the bed from the sacral region to the region of the thoracic spine of the patient, pressure will be detected by the sensor irrespective of the attitude of the patient lying in the bed.

Another example is found in anti-crush protectors for automatic doors, where such sensors can be mounted along the free vertical edges of the door panel. These doors may, for instance, be the doors of lifts, doors on buses and subway trains, or automatic garage doors.

There are many other applications in which a thin, elongated and highly responsive pressure sensor can be used advantageously.

The present invention relates to a pressure sensor which is very thin, which can be given an extensive length, which can be manufactured cheaply and which is highly reliable in operation.

The art which lies closest to the inventive pressure sensor lies in the so-called diaphragm switches. These switches normally comprise a spacer member positioned between a rigid, non-electrically conductive substrate and an elastic non-electrically conductive upper element, said spacer member being positioned so as to space the substrate from the upper element at a given location therealong. Mutually adjacent spacing members define therebetween cavities or spaces in which the upper element can be pressed down into contact with the substrate element. Normally, only two mutually adjacent cavities are connected with one another, via an air channel, and the cavities, and also the air channel, are hermetically sealed from the atmosphere. An electrically conductive pattern is provided on the upper surface of the substrate and on the undersurface of the upper element. Respective patterns are connected to an electrical conductor which extends out from the membrane switch. When the upper element is pressed down in the region of a cavity, for instance with the aid of a finger, so as to bring the upper element in contact with the substrate, an electrical contact is made between the two patterns. This depression of the upper element of the sensor will result in a decrease in the volume of the cavity concerned and the air in this cavity is forced therefrom and into an adjacent cavity, causing the upper element to bulge outwardly in the region of this cavity. The air pressure in the two mutually connected cavities will thus rise. When the finger is removed from the upper element, part of the air will flow through the air channel back to the compressed cavity, therewith causing the upper element to be returned to its spaced relationship with the substrate. The air pressure in said cavities then returns to normal.

Such diaphragm switches, however, are not suited for use as pressure sensors partly because they comprise an upper element which is made of a plastics material or some other polymeric material and which is relatively sensitive to mechanical stresses, and partly because a large number of electrical conductors are required if the switches are to have long lengths. One serious drawback is that such diaphragm switches are unable to withstand punctiform loads applied over a long period of time. It is found that when such switches are subjected to punctiform loads of long duration, the upper switch element stretches and is consecquently unable to spring back to its original position

when the load is relieved.

These problems are avoided with the present invention, which relates to a pressure sensor comprising two elongated, thin and plate-like elements which are spaced from one another solely at given locations with the aid of a spacer member, and the sensor is so constructed that electrical contact occurs when the two elements are brought together. The spacer member is configured as a thin plate from which sections of material have been removed so as to form a number of cavities between said elements, said cavities being disposed in successive, sequential relationship along the length of the pressure sensor. The inventive pressure sensor is characterized in that all cavities are connected with atmosphere via air passages which extend in the spacer member, and in that at least a first of the plate-like elements intended to be subjected to pressure force from a person or an object is configured from a metallic, springy material; and in that the two elements are electrically conductive so that a current path will be established between two respective electrical conductors extending to respective elements, irrespective of the cavity in which the elements come into contact with one another when the pressure sensor is subjected to load from a person or an object.

The invention will now be described in more detail, partly with reference to exemplifying embodiments of the invention illustrated in the accompanying drawings, in which

Figure 1 is a cross-sectional view of a pressure sensor constructed in accordance with the invention;

Figure 2 is a plan view from above taken on the line A-A in Figure 1;

Figure 3 illustrates a pressure sensor in which the cavities have an alternative configuration;

Figure 4 illustrates a pressure sensor of curved configuration; and

Figure 5 illustrates a pressure sensor constructed for detecting rotational or twisting movement.

Figure 1 is a schematic, cross-sectional view of an inventive pressure sensor. For the sake of illustration, the various elements and members of the pressure sensor are shown spaced from one another. The sensor includes two elongated, thin and plate-like elements 1, 2, which are

spaced apart solely at given locations by means of a spacer member 3. It will be understood that the illustrated dimensions of the sensor components do not correspond with the true measurements, but have only an illustrative purpose. Figure 2 is a view of the pressure sensor in Figure 1 from above, taken on the line A-A in Figure 1. It will be seen from Figure 2 that rectangular cavities 4-8 are formed between the two elements 1, 2 in the apertured regions of the spacer member 3. The cavities are connected with atmosphere through air channels 9, 11, but are closed in other respects. The pressure sensor is constructed so that an electrical contact will be made when the two elements 1, 2 are brought into contact with one another.

In accordance with the invention, the distance member is configured as a thin plate from which sections have been removed so as to form said cavities or apertures between the elements. The cavities 4-8 are disposed in successive, sequential relationship along the length of the sensor. The air passages 9-11 extend in the spacer member. At least a first of the plate-like elements 1, 2 which is intended to be subjected to pressure force from a person or an object is made of a metallic and springy material. The two elements are also electrically conductive, so that a current path will be established between two respective electric conductors 15, 16 extending to respective elements irrespective of which cavity the elements are brought into contact with one another when the pressure sensor is subjected to load from an object or a person.

In accordance with one preferred embodiment of the invention, the cavities 4-8 have a substantially rectangular shape. In this case, that part 12-14 of the space member located between two mutually adjacent cavities 4-8 and extending perpendicularly to the longitudinal axis of the sensor has a width which is smaller than one third the length of the cavities 4-8 in the direction of the longitudinal axis of the sensor. Preferably, each said part 12-14 will have a width which is smaller than about one fifth of said length of the cavities.

According to one embodiment, the two elements 1, 2 are made from an electrically conductive material, and the electric conductors 15, 16 are connected directly to respective elements 1, 2.

According to another embodiment, one or both elements is or are provided with an electrically conductive layer 17 or pattern on the surface of said element which faces towards the other of said elements, and the electrically conductors 15, 16 are connected to a respective layer 17 or pattern, as illustrated in broken lines in Figure 1. In the case of this embodiment, an electrically insulating layer (not shown) may be provided, when appropriate, between respective elements and the conductive layer 17 or pattern, so as to insulate the pressure sensor electrically against the surroundings.

As beforementioned, Figure 1 is a cross-sectional view of the pressure sensor.

According to one particularly preferred embodiment, at least said first element 1 of the sensor is made of spring steel, preferably stainless spring steel. This will enable the pressure sensor to be subjected to punctiform loads of long duration. Despite the fact that the punctiform loading of the sensor is of long duration, the first element 1 will spring back to a flat state when the load is relieved, therewith breaking the electric contact between said elements. Furthermore, steel is highly resistant to mechanical wear and to mechanical damage. Steel is also electrically conductive, therewith obviating the need to provide an electric layer or pattern.

According to a further preferred embodiment, the distance member 3 is made from a plastics material, such as polyester or teflon.

The second element 2 of the sensor may be made of any material which is suitable for the application intended. Since the second element 2 is placed against a flat support surface, the mechanical strength of said element is of no particular significance. However, there may be occasions when the pressure sensor is used in places where no flat support surface is found. In these circumstances, the second element 2 must be made of a material and given a thickness such that said element 2 will not be bent or deformed by irregularities in the support surfacesuch as to bring the first and second elements of said sensor into contact with one another, but such that the pressure

sensor will be subjected to the load intended. The second element is preferably also made of a stainless steel and given a thickness slightly larger than the first element.

Naturally, the second element 2 may also be made very thin, and laid on a thicker carrier layer 18 of appropriate material.

The pressure sensor may also be provided with a magnetic strip 19 or a layer of glue, by means of which the pressure sensor can be held firmly to an underlying support surface.

The first element 1 has a thickness of about 0.05 to 1 mm, preferably about 0.1 mm. The spacer member 3 has a thickness of about 0.1 to 0.5 mm, preferably about 0.2 mm.

The cavities may have a size of, for instance, 40 mm x 30 mm, and said cavity defining parts 12-14 may have a width of 5 mm. These measurements, however, may be varied considerably, depending on the intended use of the pressure sensor. It is essential, however, that the dimensions of the cavities are such that in combination with the material from which the first element is made and the thickness of said first element the two elements will come into contact with one another when the pressure sensor is subjected to either punctiform load or a wide load of predetermined value. The person skilled in this art is fully capable of calculating and testing different dimensions with the intention of achieving the effect required.

Naturally, the number of cavities can be varied, depending on the desired length of the pressure sensor in each particular application.

Figure 3 illustrates a pressure sensor which includes two rows 22, 23 of cavities, these rows extending parallel to one another along the length of the sensor. Naturally, more than two mutually parallel rows of cavities may be provided. Air passages 24 are arranged in a corresponding manner to the embodiment illustrated in Figure 2.

Figure 4 illustrates a curved pressure sensor which is intended to be placed against a curved support surface. The sensor is intended to

detect a force or load 25 applied at some point along the pressure sensor, or is intended to be subjected to a bending force and therewith indicate a given degree of bending.

Figure 5 illustrates another area in which the pressure sensor can be applied. In this embodiment, the spacer member is thin in comparison with the dimensions of the cavities in the plane shown in Figure 2, and consequently when the pressure sensor is rotated, or twisted, in the manner illustrated by the arrows 20, 21, the elements 1, 2 will be brought into contact with one another subsequent to rotation of the sensor through a given angle.

This embodiment of the sensor can be used to indicate when an object has been rotated through a predetermined angle.

The following applications can be mentioned in addition to the aforementioned examples of use of the inventive pressure sensor.

The inventive pressure sensor can be used to particular advantage in monitoring the whereabouts of patients or elderly people confined permanently in the home. In this area of use, a pressure sensor is placed in the bed of a patient, between the mattress and bed/bottom, and is connected to a relay circuit. The relay circuit functions to control the supply of current to, for example, certain lamps in the same room as the bed, and optionally to other lamps installed in the building.

The relay circuit functions to ignite the lamps when the person concerned rises from his/her bed, and to extinguish the lamps when said person returns to his/her bed.

An arrangement of this kind is highly beneficial in certain instances, because the awareness of the person concerned increases when the lamps are ignited. Furthermore, such an arrangement is also of great assistance to partially sighted people, since the arrangement will obviate the need to search for the light switch.

The pressure sensor is also well suited for use in automotive vehicles,

for the purpose of controlling a safety-harness warning device, etc.

The pressure sensor can also be used as an anti-theft device, for instance in museums, by placing an article on the pressure sensor such as to bring the elements 1, 2 into contact with one another. If the article is removed, the circuit will be broken and therewith initiate an alarm signal.

The pressure sensor can also be used to indicate when the wheel of a vehicle passes a given position.

The pressure sensor can, of course, also be used to start conveyor belts etc., when articles are loaded onto the belt, as mentioned in the introduction.

It is obvious that there are a large number of areas in which the inventive pressure sensor can be used, of which some have been mentioned in the aforegoing. The present invention, however, is not restricted to any particular area of use.

The invention has been described in the aforegoing with reference to a number of embodiments of the pressure sensor.

It will be understood, however, that the pressure sensor can be modified in several ways. For instance, the cavities may be given a configuration different to that illustrated, and the air passages can be located at positions different to the illustrated positions. Furthermore, the configuration of the pressure sensor can be varied as required and desired.

Accordingly, the present invention shall not be considered to be limited to the aforedescribed embodiments, since modifications can be made within the scope of the following claims.

CLAIMS

1. A pressure sensor comprising two elongated, thin and plate-like elements which are spaced apart at given locations by means of a spacer member, said sensor being configured so that electrical contact is made when the two elements are brought together, and said spacer member having the form of a thin plate from which material sections have been removed so as to form a member of cavities between said elements, said cavities being disposed in sequential succession along the length of the pressure sensor, c h a r a c t e r i z e d in that all cavities (4-8; 22, 23) are connected to atmosphere through air passages (9-11; 24) which extend in the spacer member (3); in that at least a first (1) of the plate-like elements which is intended to be subjected to a pressure force from a person or an object is made from a metallic, springy material; and in that both of said elements (1, 2) are electrically conductive, so that a current path will be closed between two respective electrical conductors (15, 16) extending to respective elements (1, 2) irrespective of the cavity (4-8; 22, 23) in which the elements (1, 2) are brought into contact with one another when the sensor is subjected to load from an object or a person.

2. A pressure sensor according to Claim 1, c h a r a c t e r i z e d in that the two elements (1, 2) are made from an electrically conductive material; and in that said electrical conductors (15, 16) are connected to respective elements.

3. A pressure sensor according to Claim 1, c h a r a c t e r i z e d in that either one (1) or both (1, 2) of said elements are provided with an electrically conductive layer (17) or pattern on the side of said element which faces towards the other of said elements; and in that said electrical conductors (15, 16) are connective to respective layers (17) or patterns.

4. A pressure sensor according to Claim 1, 2 or 3, c h a r a c t - e r i z e d in that at least said first element (1) is made of a spring steel, preferably a stainless spring steel.

5. A pressure sensor according to Claim 1, 2, 3 or 4, c h a r a c t e r i z e d in that the spacer member (3) is made of a plastics material, such as polyester or teflon.

6. A pressure sensor according to Claim 1, 2, 3, 4 or 5, c h a r a c t e r i z e d in that said cavities (4-8; 22, 23) are substantially rectangular in shape; and in that the spacer member (3) located between two mutually adjacent cavities and extending at right angles to the longitudinal axis of the pressure sensor has a width which is smaller than one third of the length of the cavities (4-8; 22, 23) in the longitudinal direction of the sensor.

7. A pressure sensor according to Claim 1, 2, 3, 4, 5 or 6, c h a r a c t e r i z e d in that the sensor includes two or more rows of cavities (22, 23); and in that the rows of cavities extend parallel with one another along the length of the sensor.

8. A pressure sensor according to any one of the preceding claims, c h a r a c t e r i z e d in that the first element (1) has a thickness of about 0.05 to 1 mm, preferably about 0.1 mm; and in that the spacer member (3) has a thickness of about 0.1 to 0.5 mm, preferably about 0.2 mm.

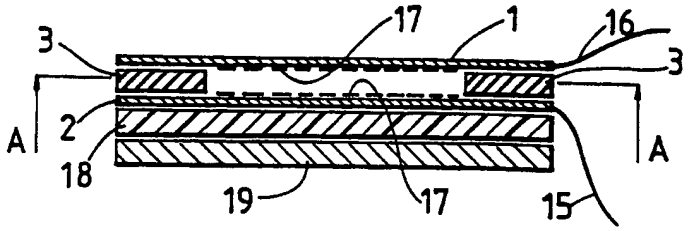

Fig. 1

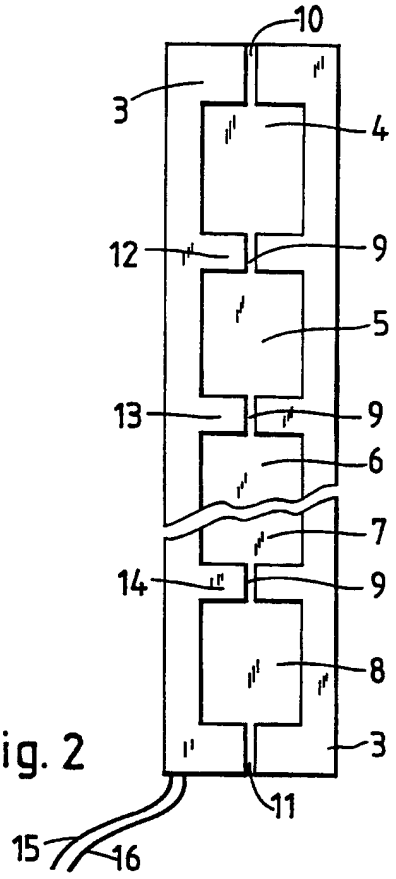

Fig. 2

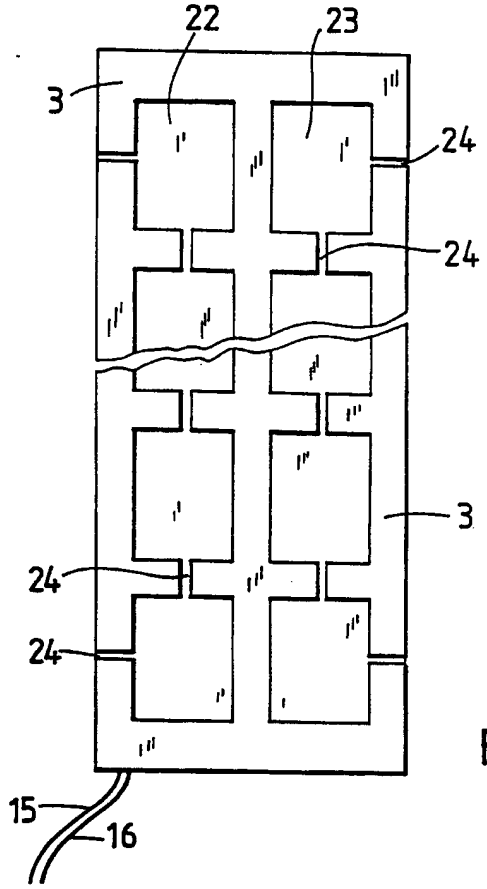

Fig. 3

Fig. 4

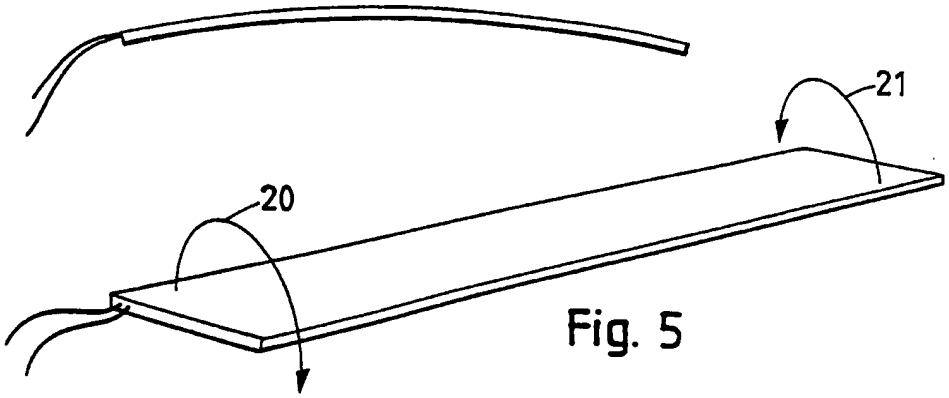

Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No PCT/SE 90/00126

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: G 01 L 1/00, G 08 B 13/10. H 01 H 35/34. H 03 K 17/96

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	G 01 L, G 08 B, H 01 H, H 03 K

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
Y	US, A, 2929893 (C. FERRY ET AL) 22 March 1960, see the whole document --	1-8
Y	US, A, 3710054 (R.H. KOENIG) 9 January 1973, see the whole document --	1-8
Y	US, A, 3821500 (B.G. NEWMAN) 28 June 1974, see abstract; figures 1-5 --	1-8
Y	US, A, 4200777 (N.K. MILLER) 29 April 1980, see abstract; figures 1-6 --	1-8
Y	US, A, 4484043 (J.L. MUSICK ET AL) 20 November 1984, see abstract; figures 1-3 --	1-8

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
14th May 1990	1990 -05- 21
International Searching Authority	**Signature of Authorized Officer**
SWEDISH PATENT OFFICE	LARS JAKOBSSON

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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	US, A, 4484038 (W.E. DORMAN ET AL) 20 November 1984, see abstract; figures 1-4 --	1-8
Y	US, A, 4365130 (D.A. CHRISTENSEN) 21 December 1982, see the whole document --	1-8
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Y	US, A, 4456798 (S.H. IWAI ET AL) 26 June 1984, see the whole document --	1-8

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.PCT/SE 90/00126

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the Swedish Patent Office EDP file on 90-05-07 The Swedish Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
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